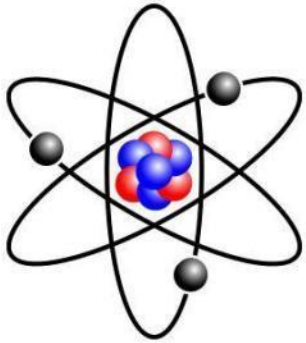
Applications of particle accelerators



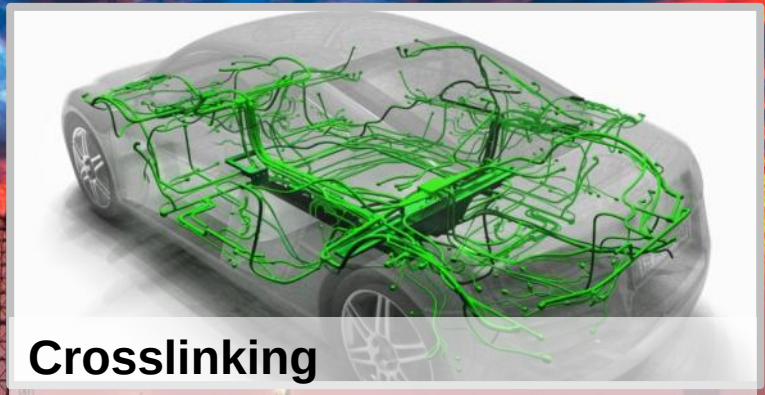
Stepan Shirkov
AYSS - Alushta - 2022

Applications

- Science
- Industry
  - Sterilization of medical and pharmaceutical products
  - Phytosanitary processing of products
  - Cold pasteurization of food
  - Sanitization of correspondence
  - Safety
  - Modification of polymers/crosslinking (pipes, wires and cable sheaths)
  - Oil cracking
  - Coloring glass and gems
  - Ecology
  - Doping of semiconductors
  - Filters production
- Medicine
  - Diagnostics
  - Therapy

INDUSTRIAL APPLICATION

Sterilization

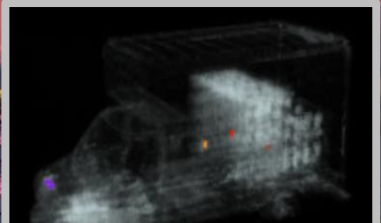


Crosslinking

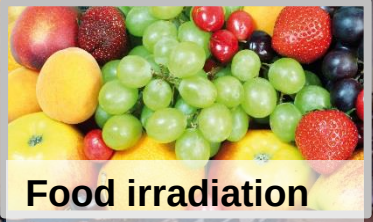
Mail Sanitization

Gemstones

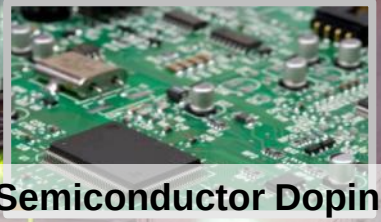
Filters



Cargo Screening



Food irradiation



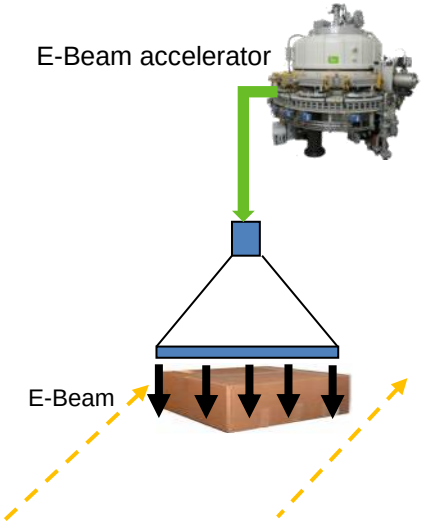
Semiconductor Doping

Sterile Insect

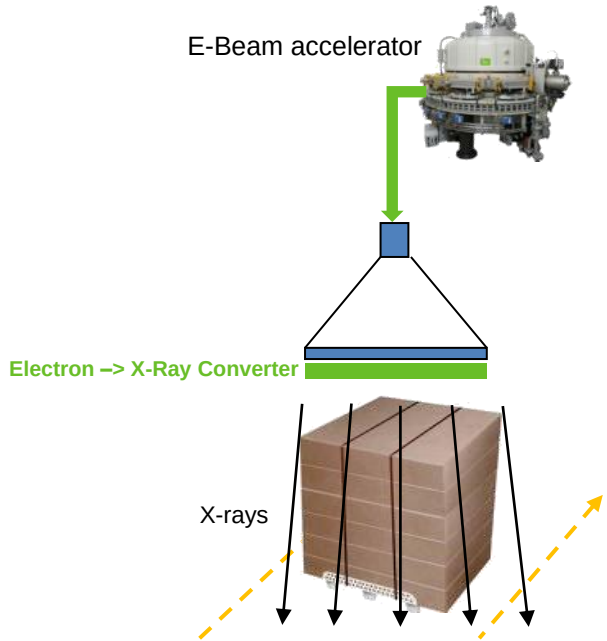
Ecology

Sterilization and bacteria deactivation

E-beam



X-ray



Wire & cable Crosslinking

Utilities

- Underground EHV, HV dc/ac
- Submarine EHV dc/ac (extruded, laminated, PPL, O.F.)

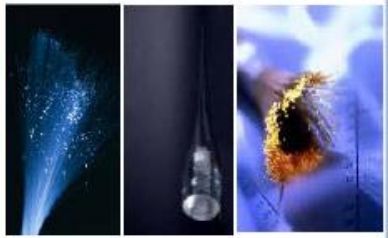
- MV "P-Laser^{R}"
- Network components (from MV to EHV joints and terminations)

T&I
Trade & Installers

- LV cable for residential and non residential construction
- Wide range of product including:
  - Fire retardant
  - Environmental friendly
  - Application specific products
  - Low smoke-zero halogen (LS0h)

Telecom

- Coaxial cables (CATV)
- Last mile micro duct optical cables (Jet Net^{R})
- Bend bright optical fiber
- EPFU (Enhanced Performance Fibre Units) telecom cables, data cables
- Micro modules based tlc cables
- Connectivity (FTTH)

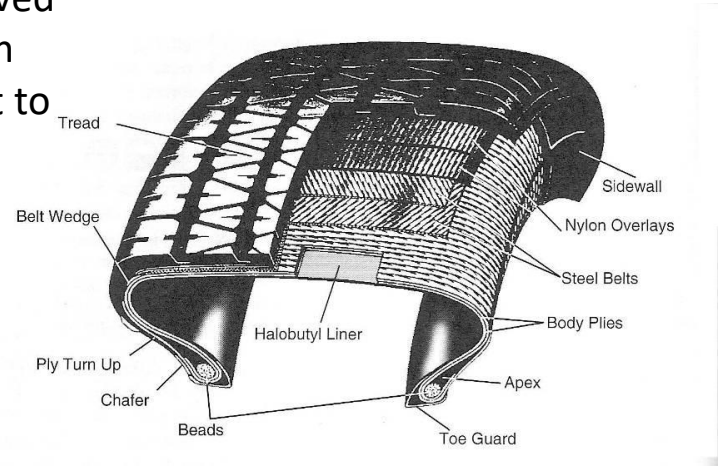


High-end Industrials

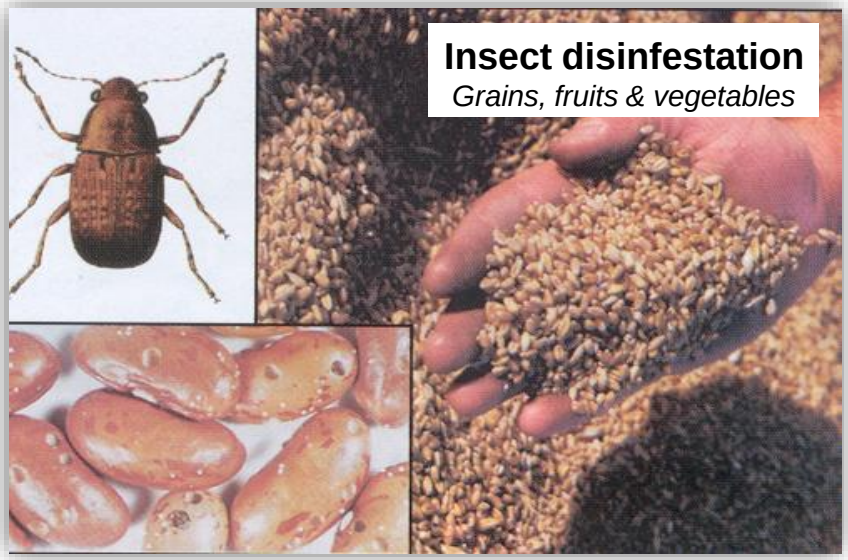
- On-shore and off-shore wind farm
- Aerospace and automotive
- Umbilicals, flexible pipes
- Elevators cables
- Oil & gas, crane, mining cables and solar
- Railway & rolling stock

Crosslinking in tires industry

- Benefits of E-beam for tires
  - Reduction in material hence in the weight of the tire
  - Relatively low cost synthetic rubber can be used instead of costly natural rubber without a loss in strength
  - The radiation pre-vulcanization of body ply is achieved by simply passing the body ply sheet under the scan horn of an electron accelerator to expose the sheet to high-energy electrons
  - Higher production rates
  - Construction of green tires
  - Reduction of production defects



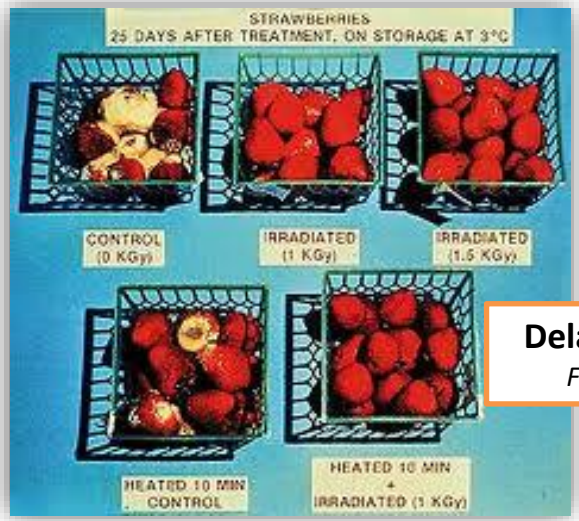
Food irradiation



Insect disinfestation
Grains, fruits & vegetables

Alternative to chemical banned fumigation such as ethylene dibromide

Sprouting inhibition
Onions, potatoes, ...



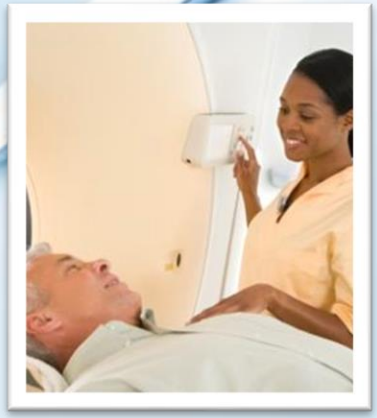
Delay of Maturation
Fruits & vegetables

Food irradiation

Inactivation of pathogenic bacteria
Salmonella, E-coli 157, listeria, …

Extension of shelf life
Deep frozen products, spices, …

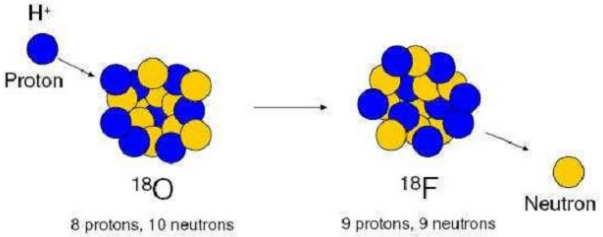
MEDICAL APPLICATIONS



Treatment

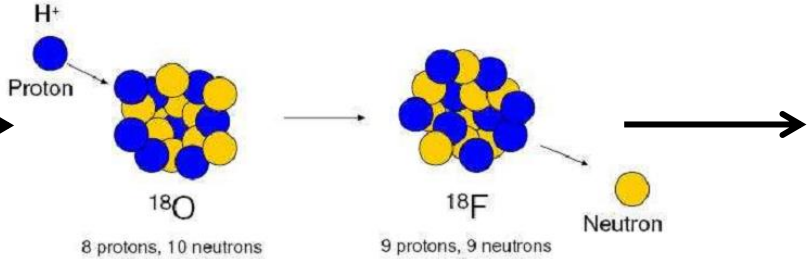
Diagnosis

Diagnosis applications - Radiopharmaceutical

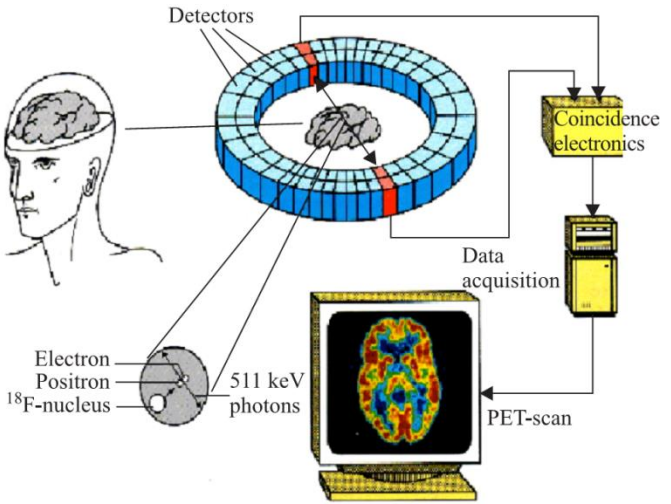


Изотоп	Время жизни изотопа	Тип ядерной реакции	Энергия протонов, МэВ	Выход, мКи/мкА·ч	Применение
^{11}C	20 мин	^{14}N$(p,\alpha)^{11}$C	10	20	ПЭТ
^{13}N	10 мин	^{16}O$(p,\alpha)^{13}$N	11		ПЭТ
^{15}O	2 мин	^{15}N$(p,n)^{15}$O/^{14}N$(d,n)^{15}$O	10	21	ПЭТ
^{18}F	1,8 ч	^{18}O$(p,n)^{18}$F	10	30	ПЭТ
^{44}Sc	60 мин	^{45}Sc$(p,n)^{44}$Ti (48 лет)→ →^{44}Sc	30		ПЭТ-генератор
^{52}Fe	8,3 ч	^{55}Mn$(p,4n)^{52}$Fe	80 → 50		Гематология
		^{52}Cr(^{3}He,3n)^{52}Fe	36 → 25		
^{64}Cu	12,7 ч	^{64}Ni$(p,n)^{64}$Cu	14 → 9	6,5	Молекул. ПЭТ
^{67}Ga	78,3 ч	^{66}Zn$(p,n)^{66}$Ga→^{67}Ga	15 → 10		Диагностика опухолей
^{68}Ga	68 мин	^{69}Ga$(p,2n)^{68}$Ge (генератор 270 сут)→^{68}Ga	35		
^{73}Se	7,1 ч	^{75}As$(p,3n)^{73}$Se	40 → 30		Селенофарм.
^{76}Br	16 ч	^{75}As(^{3}He,2n)^{76}Br	25 → 15		Бромофарм.
		^{76}Se$(p,n)^{76}$Br	16 → 8		ПЭТ
^{77}Br	2,8 сут	^{78}Kr$(p,2n)^{77}$Rb→ →^{77}Kr→^{77}Br	30		SPECT-диагностика
^{73}Se	7,1 ч	^{75}As$(p,3n)^{73}$Se	40 → 30	38	
^{81}Rb	4,6 ч	^{82}Kr$(p,2n)^{81}$Rb	30		SPECT
^{82}Rb	1,3 мин	^{82}Sr (генер. 25,5 сут)→ →^{82}Rb			ПЭТ коронарные
^{86}Y	14,7 ч	^{86}Sr$(p,n)^{86}$Y	14 → 10	54	ПЭТ
^{103}Pd	17 сут	^{103}Rh$(p,n)^{103}$Pd	14 → 7	0,18	Брахитерапия
^{111}In	2,8 сут	^{112}Cd$(p,2n)^{111}$In	22		Диагност. метка
^{123}I	13,2 ч	^{124}Xe$(p,2n)^{123}$Cs→ →^{123}Xe→^{123}I	30	0,19	SPECT-тироид
^{124}I	4,18 сут	^{124}Te$(d,2n)^{124}$I	14 → 10	0,47	Дозиметрия
		^{124}TeO$_2(p,n)^{124}$I	13 → 9	0,45	Эндотерапия
		^{125}Te$(p,2n)^{124}$I	21 → 15	2,19	ПЭТ
^{140}Nd	3,4 сут	^{140}Pr$(p,2n)^{140}$Nd	10 → 30		Радиотерапия
^{195m}Pt	4 сут	^{192}Os$(\alpha,n)^{195m}$Pt	10 → 25		Радиотерапия
^{201}Tl	3,06 сут	^{203}Tl$(p,3n)^{201}$Pb→^{201}Tl	29		Диагн. кардиолог.
^{225}Ac	10 сут	^{226}Ra$(p,2n)^{225}$Ac	15	~ 0,19	Радиотерапия

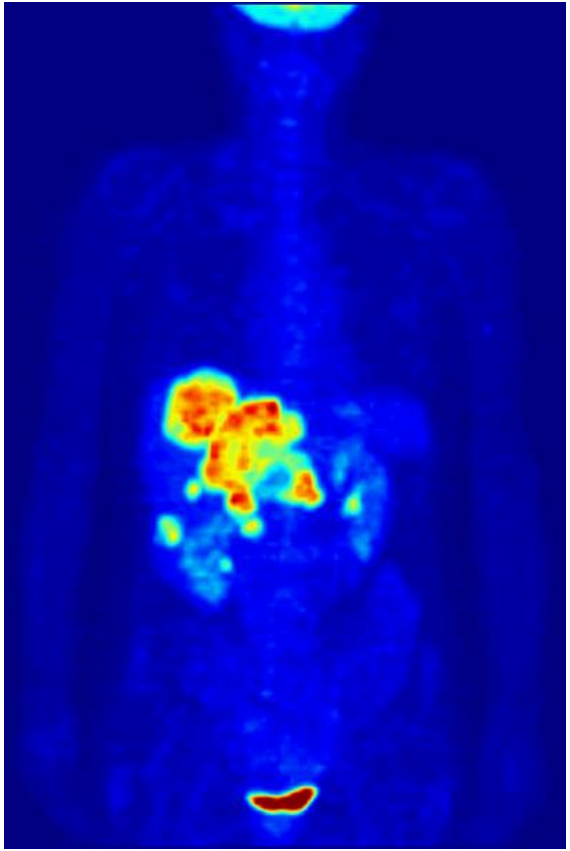
Obtaining of radiopharmaceuticals

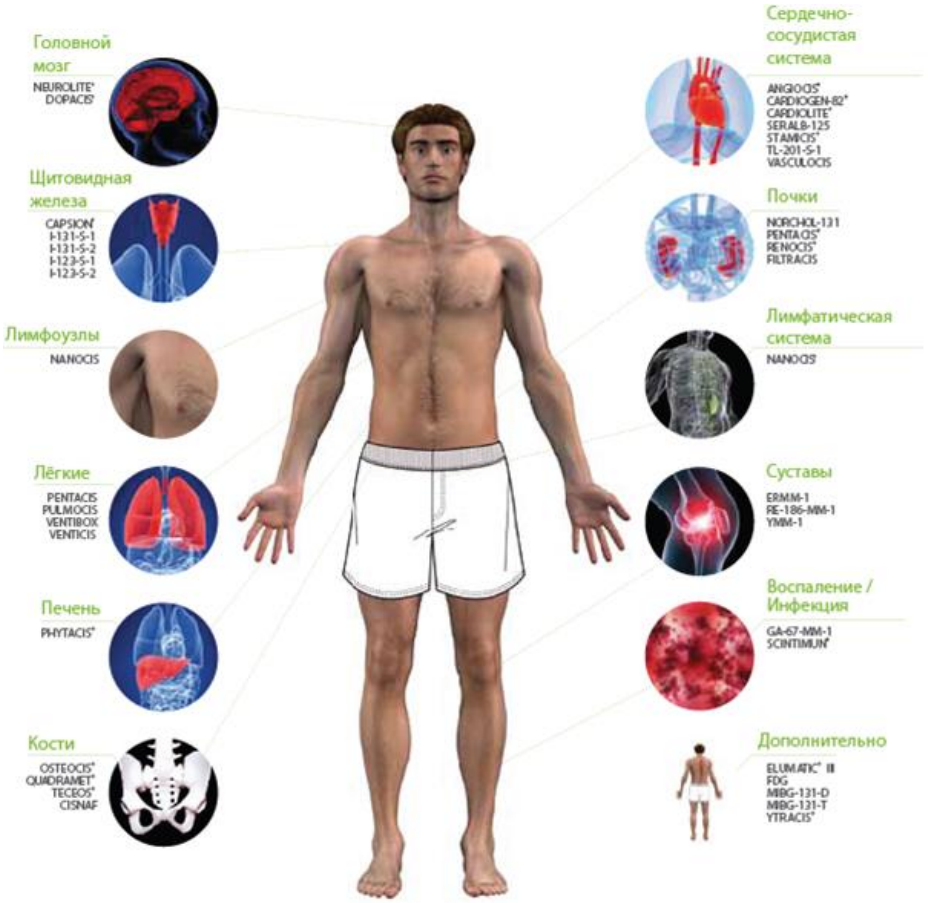


PET research



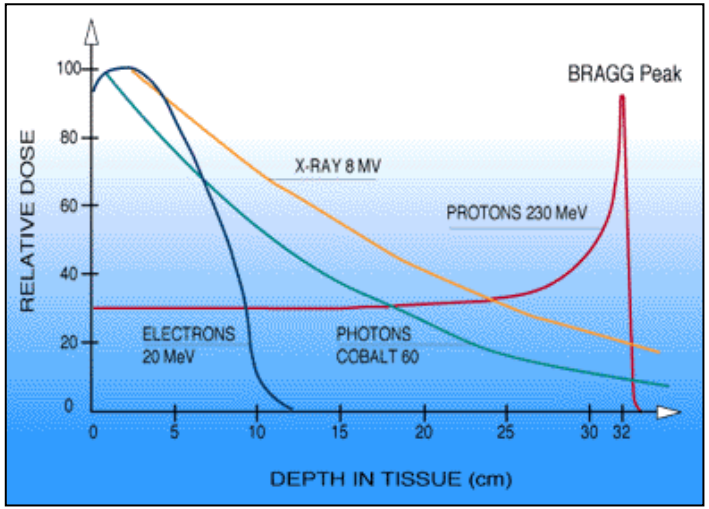
Visualization



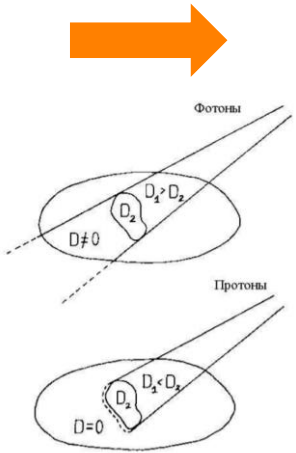


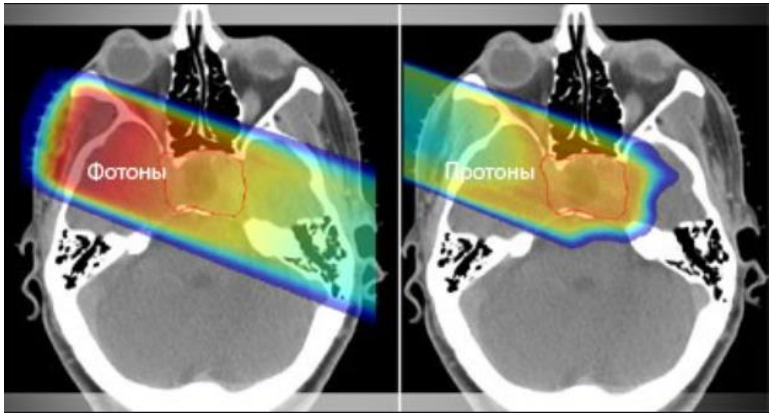
Radiation therapy

Dose field distribution for different types of radiation



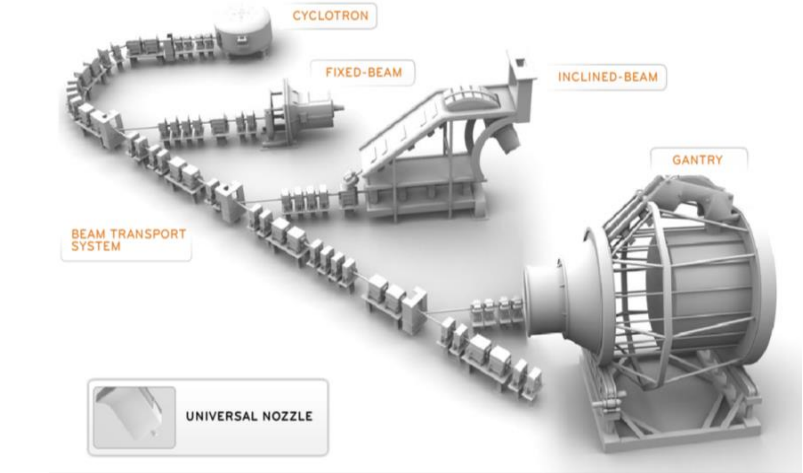
Depth distribution of the absorbed dose in water for different types of ionizing radiation





Qualitative comparison of doses generated in different areas by beams of photons and protons

Proton therapy



JINR

Innovative Research Proton Center of Radiation Biology and Medicine

Innovative Research Proton Center of Radiation Biology and Medicine

- **Flash method of proton therapy**
  - The study of dose rates, total single doses and other parameters of the proton beam, which lead to the appearance of a flash effect in pathological tissues and their surrounding structures in vivo.
  - Flash detectors, ionization chambers.
- **Radio modifiers and radio protectors**
  - The study of the action of existing and well-known radiomodifiers (amino acids, for example) and physical effects (hyperthermia) in combination with proton beam therapy.
- **Gamma imaging for protons**
  - Creation of devices and methods for measuring gamma radiation fluxes arising from the interaction of therapeutic proton beams with the patient's body.
- **Quality control of treatment**
  - Program methods for quality control of treatment plans for irradiation, as well as the quality of work of all nodes and elements of the proton beam therapy system.

Thank you for your attention!